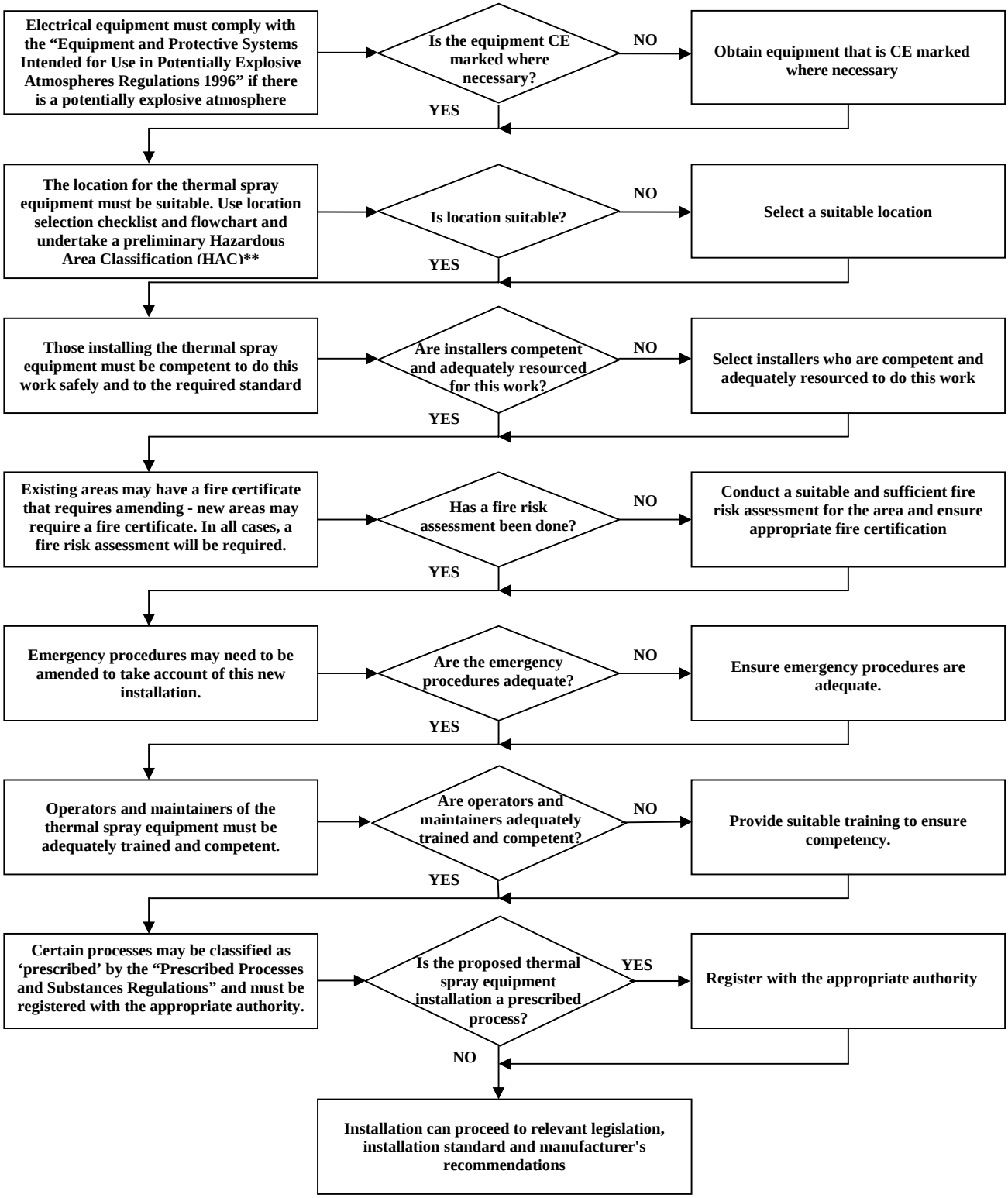
Appendices: Worked Examples

The following pages contain some worked examples, based on actual installations. There are also some checklists and flowcharts, which may help you to undertake your own risk assessment. However, it must be stressed that the circumstances relating to each installation are unique, and you must apply the principles to your own situation, which may well differ in significant ways from those described.

Contents

Example 1: Thermal spray equipment pre-installation flowchart



** Preliminary HAC estimates potential release sources and zoning to allow potential problems to be 'engineered out' before installation.

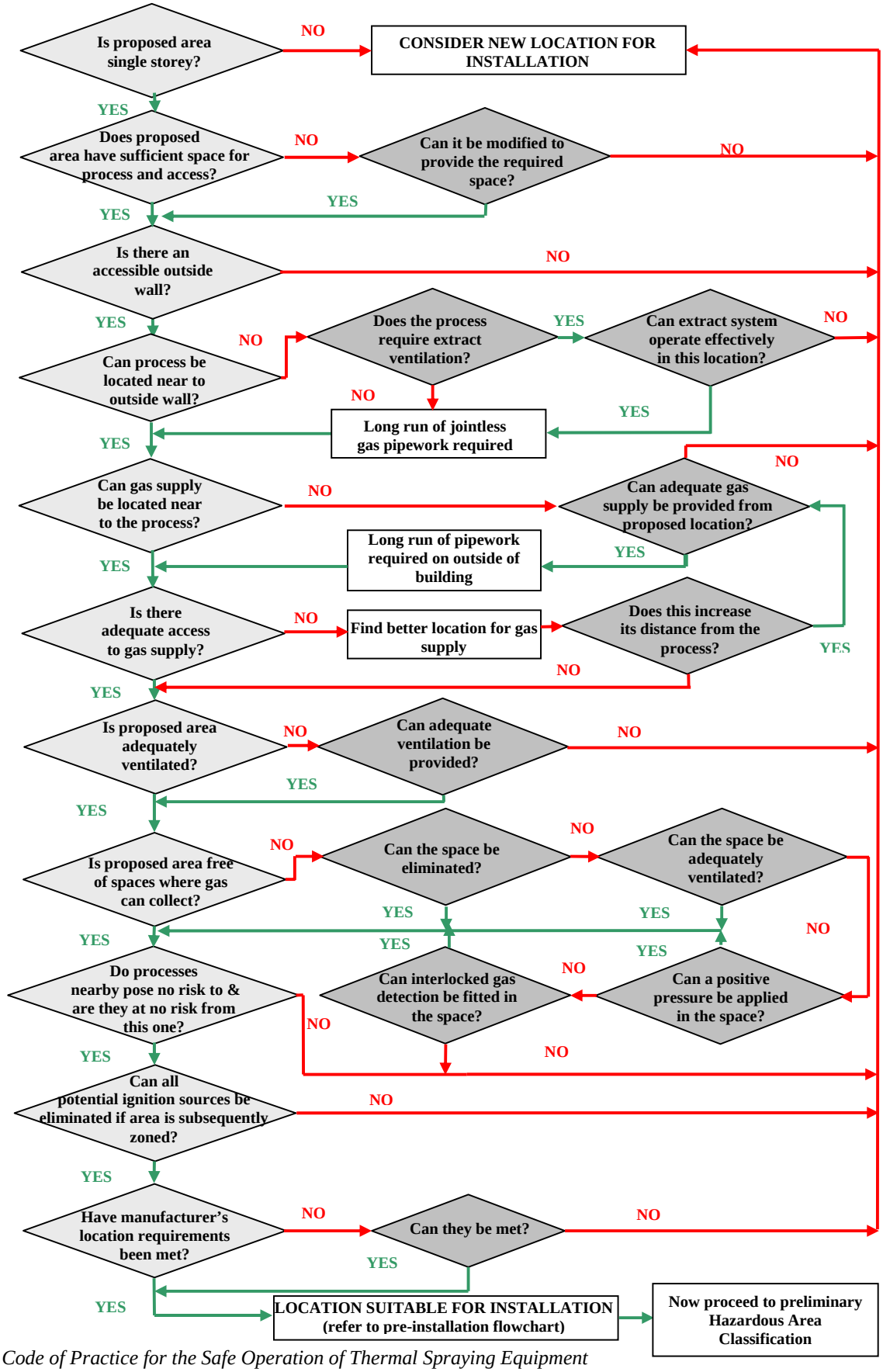
Example 2: EQUIPMENT LOCATION SELECTION CHECKLIST, for installations where flammable gases/fuels are to be used. (to be used in conjunction with the location selection flowchart and pre-installation flowchart)			
Nº	Question	Y/N	If answer is NO, list remedial actions or consider new location
1.	**Is the proposed area single storey?**		
2.	**Does proposed area have sufficient space for process and suitable access?**		
3.	**Is there an accessible outside wall?**		
4.	**Can the process be located near to outside wall?**		
5.	**Can the gas supply be located externally, near to the process? (Note: care is needed in locating a gas that can re-liquefy)**		
6.	**Is there adequate access to gas supply?**		
7.	**Is proposed area adequately ventilated?**		
8.	**Is proposed area free from spaces where gas can collect?**		
9.	**Do processes nearby pose no risk to and are they at no risk from this process?**		
10.	**Can all potential sources of ignition be eliminated if the area is subsequently zoned?**		
11.	**Have manufacturer's location requirements been met?**		

Type of Installation: …… Proposed Location: ……

Assessor's Name: …… Assessor's Signature: …….. Date: ……

Example 3: EQUIPMENT LOCATION SELECTION FLOWCHART

For installations where flammable gases/fuels are to be used



Example 4: An Example of Zoning after Hazardous Area Classification

High Velocity Oxy-fuel (HVOF) and Plasma Spray Area

New equipment, to be installed in an existing single-storey open plan building. There are two spray booths:

HVOF:

Supplied with, and capable of operating with, acetylene, hydrogen, kerosene or propylene. The fuel is supplied from external storage, the kerosene (flash-point 63^{o}C) is contained in a small header tank on an outside wall, the acetylene, hydrogen, propylene and oxygen are supplied from an external cylinder gas storage area. (Note, care will be needed in locating any gas that can liquefy). The storage area is of 'breeze-block' construction and each gas has its own bay. All pipework, from the connection at the cylinder storage and kerosene header tank, to the booth is jointless – all sections being welded or brazed (dependent on material of pipes). All regulators are located within the fully ventilated, interlocked booth that is fitted with high and low-level gas detection.

Plasma:

This is supplied with argon, nitrogen and hydrogen, coming from the cylinder gas storage area. The regulator is on the outside of the booth, but has gas detection fitted above it. The booth is fully ventilated and interlocked, with high-level gas detection fitted.

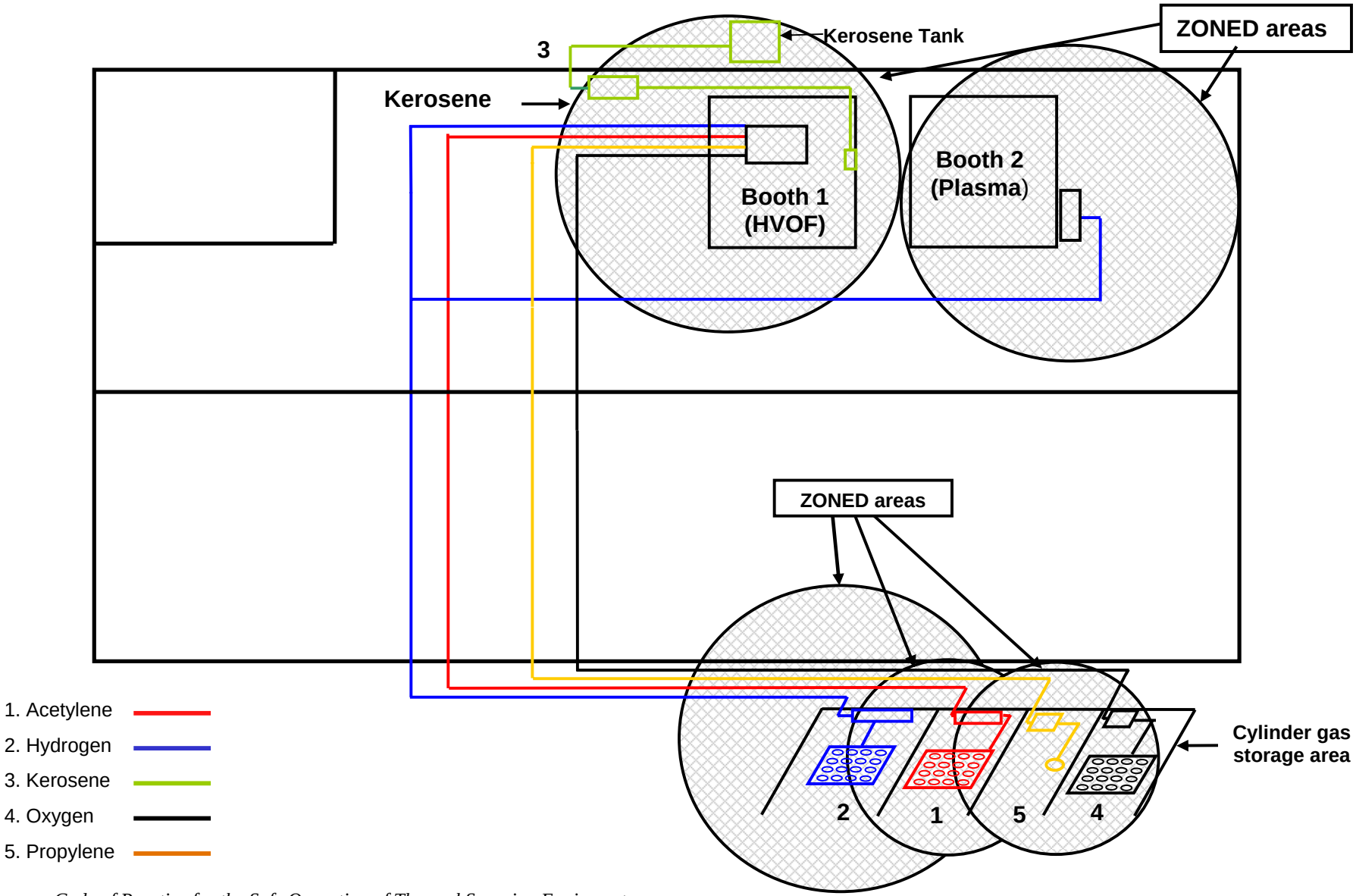
The gas mixing units on both the HVOF and Plasma Spray facilities are separate from the control panel, thereby minimising the risk of ignition.

The general ventilation in the area is less than adequate, but work is in progress so that the booths take some of their 'make-up' air from within the building itself, thus improving the level of general ventilation and reducing the extent of the zones. **

The following page shows the Zones that resulted from the Hazardous Area Classification (HAC).

** The effect of reducing the extent of the zone was to remove the need to modify electrical apparatus, because it was now outside the zoned area. The plant cannot be used until the ventilation modifications, i.e. interlocking with the electrical supply, have taken place. It should be noted that the integrity of ventilation systems is critical where safety is totally dependent on its operation.

HAZARDOUS AREA CLASSIFICATION ZONE DIAGRAM OF HVOF/PLASMA SPRAY FACILITIES



Example 5: Checklist for the Installation and Commissioning of a Fully Enclosed Thermal Spray Booth

Fully enclosed Thermal Spray Booth (controlled externally via interface)

Identify the hazards of the process, which may include:

	YES ✔	NO ✕
Flammable/explosive gases or liquids	☐	☐
Pressure	☐	☐
Dust and Fumes	☐	☐
Ultra Violet Radiation	☐	☐
Fire, explosion	☐	☐
Physical Hazards i.e., hot material, tripping	☐	☐
Electric shock	☐	☐
Noise	☐	☐
Electrostatic discharge	☐	☐

Considerations when installing the process:

Conduct pre-installation inspection of the work area

- Consider where the compressed gas pipelines will be situated. Aim to reduce sources of release to an absolute minimum, e.g. by the use of welded or brazed joints. This can be aided by installing the maximum amount of pipe work and connections that carry flammable/explosive gases on the outside of the external walls to the buildings. YES ☐ NO ☐

- Locate compressed gas cylinder storage area out of doors, and identify and locate suitable emergency shut off valves. YES ☐ NO ☐

- Ideally, the proposed compressed gas storage area must be located adjacent to an external wall of the building. YES ☐ NO ☐

- Identify what level of ventilation is available in the area and its impact on the HAC. The greater the level of ventilation the lower the risk of creating a potentially explosive atmosphere (should a release of flammable gas occur) YES ☐ NO ☐

- Ensure the roof of the building is not designed in such a way that any released gases could be trapped in voids or similar structural features. Ensure there are no cellars, pits, trenches also. YES ☐ NO ☐

- Consider what sources of ignition exist within the proposed work area. Ask yourself can they be eliminated, removed, or reduced. YES ☐ NO ☐

Considerations during Installation of the process

- Have competent persons been employed to install the pipe work and gas storage facility? Is the system installed to British Compressed Gas Association (BCGA) standards and fitted with slam-shut valves and flash back arrestors etc? YES ☐ NO ☐
- Review the work equipment being installed to ensure its safety, does the equipment have a 'CE' mark affixed? YES ☐ NO ☐
- Consult with the equipment supplier and/or manufacturer as to the proposed location of the equipment. YES ☐ NO ☐
- Is there adequate control of the contractors/suppliers working on the system, taking account of the HS&E requirements? YES ☐ NO ☐

Obtain additional relevant information from the equipment suppliers

- Is the equipment/system fitted with suitably located and sufficient emergency stops to ensure the system can close down safely and quickly in an emergency? YES ☐ NO ☐
- Are all the emergency stops linked to ensure that if one is activated, then all the system closes down safely? YES ☐ NO ☐
- If the equipment detects a safety critical fault, e.g. a flammable gas leak, a failure in the purge air system or similar will the equipment close down automatically to a safe condition? YES ☐ NO ☐
- What gas detection units will the equipment supplier be installing, and what are the locations within that equipment? YES ☐ NO ☐
- Is the electrical equipment that is located within a potentially explosive atmosphere suitable to be used in this type of environment in line with the HAC? YES ☐ NO ☐
- Identify if the local exhaust ventilation (LEV) fitted to the spray booths is interlocked to the gas supply, i.e. when the LEV is not operating then the gas will not be supplied. YES ☐ NO ☐

- Is the exhaust air flow rate monitored? YES ☐ NO ☐

- Obtain a copy of the information that the equipment supplier has prepared for the customer to indicate how he has complied with each of the Essential Health and Safety Requirements under the Supply of Machinery Regulations, and other relevant Regulations?[20] (Note: the full information is confidential, but he should be able to state the standards to which the equipment conforms). YES ☐ NO ☐

- Identify noise emission levels supplied by the equipment supplier YES ☐ NO ☐

Considerations when the installation has been completed

A written scheme of examination should be obtained for the complete system from a competent person. YES ☐ NO ☐

The recommended service, maintenance and repair requirements specified by the manufacturer should be identified and implemented. YES ☐ NO ☐

The Fire Certificate applicable to the premises will need to be amended to reflect the alterations made to the building. Any fire risk assessments should be reviewed to ensure they accurately represent the status of the building. YES ☐ NO ☐

Any site emergency procedure should be amended to reflect the current location of the equipment and the associated hazards. YES ☐ NO ☐

Appropriate warning signs will need to be installed around the work area to warn of hazards relating to the process. YES ☐ NO ☐

Has suitable training been given to the operator of the equipment? YES ☐ NO ☐

Ensure other possible ignition sources are not in introduced into the area after the installation has been completed, e.g. battery charging. YES ☐ NO ☐

Having completed the installation of the equipment and associated pipe work, a hazardous area classification is required. This identifies the sources of release and grade of YES ☐ NO ☐

release and ultimately allows the user of the equipment to zone the area.

Having completed the hazardous area classification using BS EN 60079-10[18] the appropriate electrical equipment can be selected for use in the work area from BS EN 60079-14.[51]

YES ☐ NO ☐

Carry out a noise assessment

YES ☐ NO ☐

Foreseeable causes of incidents

Leakage of flammable gases due to damaged hoses or connectors.
Leakage due to inadequate design, specification or installation of associated equipment.
Failure to secure joints/connections.
Inadequate ventilation
Failure to undertake 'leak testing' on the systems joints/ connections
Contact with Plasma/Combustion Arc or hot components
Safety devices bypassed or overridden
Failure to inspect, and/ or maintain equipment
Ignition caused by naked flame, smoking or unsuitable electrical equipment/fittings.
Failure to follow safe system of work.

Consequences

Fire and/or explosion leading to: -
fatality, blindness, noise induced hearing loss, loss of limb, burns, laceration, bruising, etc and/or damage to buildings plant or equipment
Business interruption, industrial relations problems, adverse publicity.

Example 6: System of work for spraying operations in an extracted booth

Note: this case study refers to an existing system. In new installations, a higher standard of interlocking is required, see Worked Example 5.

Installation
Plasma and HVOF units have been sited in an extracted booth. The spraying equipment is manipulated by a robot. Components are either manipulated by an indexing turntable or held stationary in a fixture. Components are manually loaded into the booth and processed in a sealed booth via control panels outside the booth in a semi-automatic operation. This booth does not have its extraction system interlocked with the gun controls, and hence the risk of explosion or asphyxiation from gases within the booth, which may have accumulated due to a leak, is controlled by a system of work based on a risk assessment.

Start up procedure
1. Turn on extraction prior to entry, and allow time for 5 volume changes.
2. Ensure booth is in a safe condition to operate access, equipment, gun condition, etc.,
3. Power up equipment and check function prior to use.

Operation
1. Before loading components, ensure equipment is safe, i.e. spray unit is non-operational, robot is locked out. A safe working system is required for operators to enter the booth if either or both the spray equipment and robot is in operation. E-stops should be positioned in booth.
2. Provision should be made for loading/unloading of large parts, parts of awkward shape or parts with sharp edges. Rotating parts should be tooled to minimise risk of slippage from rotation unit.
3. Access and escape routes from the booth should be marked and kept clear.
4. Check operation of equipment, ensure air-lines, powder lines, power cables etc are free to allow equipment movement without catching.
5. Ensure extraction, which in the case of a new installation should be interlocked, is in operation prior to spraying, and has been in operation long enough to achieve 5 volume changes of air in the booth.
6. Access to booth should be restricted whilst equipment is in operation, e.g. by interlocking.
7. Noise levels should be measured and operator noise exposure assessed. Hearing protection should be issued as required. Signs should be erected.
8. After spraying sufficient time should be allowed for extraction unit to evacuate dust and fumes. Provision should be made to either allow parts to cool before handling or personal protective equipment should be provided to handle hot parts.
9. Consider relevant personal protective equipment for the handling of powders and filling hoppers. This should also be considered during the cleaning up of spills and during cleaning of booths.
10. Disposal of waste powder should be controlled, in respect of dust release and hazardous wastes.

Shut down
1. Leave booth in a safe condition, i.e. no trailing hoses or cables.
2. Power off and turn off gases at source; then purge out pressurised lines and turn off water cooling.

Example 7: Spraying in an open workshop using a lathe to traverse the work piece (any thermal spray system)

Operation in an open workshop makes greater demands on the system of work and personal protective equipment. The employer must carry out a risk assessment, and this must address at the very least noise, ultraviolet radiation (for plasma or arc spray), dust and fume, ignition hazards, and physical hazards such as tripping and burning.

Location
Without the benefit of a purpose built booth, the operation should be sited carefully and the timing of spraying operations may need to be tailored to the needs of others. The noisiest spraying operations are not suitable to locations close to people. Hazardous Area Classification is required to define safe distances between the operation and any flammable or combustible materials. It will also determine the distance that it must be from any electrical switchgear, and the zone within which the electrical apparatus must be of approved type.

Ventilation
The user must undertake a risk assessment to ensure that control of exposure to fume and dust is in accordance with the Control of Substances Hazardous to Health Regulations.[10] Adequate precautions must be taken to control exposure to dust and fume and to ensure that concentrations of flammable gases cannot build up to dangerous levels. Forced ventilation should be used wherever reasonably practicable, but in some instances where the risk is very low it may be handled by segregation and natural ventilation. Typically forced ventilation should take the form of an extractor hood or flanged slot mounted along the length of the lathe in line with the spray system traverse and positioned to receive dust from the rotating lathe. The air should be extracted at a rate that captures dust effectively, typically 1 m/s at the lathe. Extraction efficiency and running costs can be optimised by siting the opening close to the workpiece and enclosing as much of the lathe as is reasonably practicable. If forced ventilation is required then it must be started sufficiently in advance of spraying and stopped with sufficient delay after cessation of spraying to ensure that dust, fume and gases have been adequately dispersed.

If it is not practicable to ensure respirable air by means of ventilation, then suitable personal protective equipment shall be used by all at risk. For the operator in particular, respiratory protective equipment will almost certainly be required, for example an air-fed helmet. The supply air must be of breathable quality, free from fumes and oil mists and meeting BS EN 12021 (formerlyBS4275).[58] All skin should be covered, as dust can irritate the skin.

Connections
Setting up must be in accordance with the equipment manufacturer's instructions. Whenever a piece of equipment is moved connections will be undone and re-made. It is essential that all connections are checked to ensure their integrity. Gas connections should be leak tested and electrical connections should be checked visually. Bear in mind

that in arc processes currents of many hundreds of Amps can flow and that badly made joints can generate enough heat to melt the metal connections. No gas connection should be over-tightened. If a gas connection still leaks after a reasonable force has been used then the fitting is damaged or faulty and must be replaced.

Often, when operating in an open workshop, some part of the machine such as the power supply may be remote. This leads to trailing leads and the possibility of tripping accidents. The trailing leads or hoses are much more prone to accidental damage, which may lead to a gas leak or electrical fault. Leads should be as short as possible and have flexible armouring where they are liable to be damaged. Power leads and gas hoses should never contain joints.

Spraying
Care must be taken to ensure that any spray or over spray does not impinge on any flammable or degradable materials. A sheet of metal may be used as a backstop, or a temporary booth if available.

Noise
A simple hanging PVC barrier can attenuate the noise by up to 10 dB, so that hanging temporary barriers round the work can have a significant effect. The operator will almost certainly need hearing protection, and a noise assessment is advised. Absorptive acoustic barriers may be erected around the machine.

Ultraviolet Radiation
For any process producing UV light, eyes must be protected. For plasma spraying a shade 9 welding filter, according to BS EN 169[57], or for arc spraying a shade 6 is the minimum. Fast reacting welding masks of the relevant shade may also be used. The radiation from plasma spraying may cause skin damage through light clothing, so thick or aluminised clothing is required. Scattered radiation can affect the line between gloves and sleeves, and the underside of the chin and nose.

Shutdown
Turn off gas at source and back off the regulators, purge and depressurise the lines, leave the ventilation on to clear the fume.

Training and competence
During all stages, the operations must be carried out by competent persons. This is true for the risk assessment itself, and all the installation work.

Example 8: A Risk Assessment and Method Statement for a Spraying Operation Carried Out on Site - Anti Corrosion Treatment Using Zinc

Hazard	Risks	Persons Affected	Control of Risk
Metal Spraying & metal fume fever	Respiratory problems, eye injury	Metal spray operator	Work is carried out in a fully enclosed cubicle that has extraction fitted within it. The operator is supplied with full protective equipment.
Overhead crane usage, using slings etc	Falls of loads from slings due to incorrect slinging. Overloading of cranes. Head injury	Operatives and employees in the area	Operators have received slings and lifting training. All persons must wear head protection at all times.
Grit blast process, dust, flying grit	Eye injury, respiratory problems	Grit blast operator	Operator supplied with full protective equipment and work is carried out within a fully enclosed cubicle
Noise	Noise induced hearing loss.	All employees and visitors within the area.	Ear protection is compulsory for grit blast and metal spraying operators. It is recommended for others in the near vicinity with noise exposures between 85 and 89 dB(A). (Subject to a noise assessment)
Falls from height	Injury, possibly fatal	Employees and contractors working on platforms, scaffold or ladders	Free-standing scaffold platforms and towers are used which provide protection from falls
Use of ladders	Injury, possibly fatal	All employees within the area	Ladders must be non-conductive (e.g. wood, polypropylene) and be footed by another employee or tied at the top.
Air compressors	Failure of compressed air reservoir	Employees within shop and sprayer	The maintenance engineer maintains compressors and they are inspected daily

Hazard	Risk	Persons Affected	Control of Risk
Paint application by brush/roller techniques Xylene fume	Respiratory problems, flammable vapours (serious explosion risk with xylene)	All employees and visitors within vicinity of the works	A COSHH assessment must be carried out together with air monitoring details, and measures instituted to control exposure. These are in a separate file. Painters are provided with all the necessary protective equipment. Antistatic precautions may need to be made when handling xylene.
Fire	Burns, smoke inhalation	All employees and visitors within the vicinity of the works	All employees must receive training in the use of fire extinguishers. NO SMOKING POLICY APPLIES
Housekeeping fire hazards	Fire, tripping hazards	All employees	Tins of paint and flammable items are kept in a separate area. NO SMOKING applies in the area at the works. The working area is kept clean and tidy on a daily basis.

Method Statement

Phase 1
Erect working enclosure – to be carried out by others
Grit blast to remove dirt and existing paint using wet blasting techniques
Clear debris and spent abrasive, place in closed containers
Inspection by third party; repairs to be carried out (by others) if required

Phase 2
Connect extraction unit to tented area
Grit blast
Clear spent abrasive from area and ensure that surfaces are clean and dry
Inspect - taking random samples
Inspect working enclosure for damage; repair as necessary
Zinc metal spray within 4 hours of grit blasting
Inspect
Spray sealer within 4 hours of metal spraying
Inspect
Paint procedure (3 iterations)
    Apply proprietary paint
    Inspect
Remove all debris and ensure all surfaces are clean
Conduct final inspection
Dismantle working enclosure
Issue certificate of conformity and all coating treatment records